Beach Wizard
Development of an Operational Nowcast, Short-Term Forecast System for Nearshore Hydrodynamics and Bathymetric Evolution.

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LONG-TERM GOALS

The long-term goals are to provide accurate and detailed predictions of nearshore hydrodynamics and bathymetric evolution using an advanced process-based model (Delft3D). Observations of dense remotely-sensed and sparse *in situ* data will be assimilated to continuously improve model performance, and where the data is uncertain or absent, the model will be used to fill in the gaps and construct a more complete estimate of current or near-future conditions.

OBJECTIVES

The objectives of the proposed study are to:

- Develop methods for estimating relevant Delft3D model inputs and outputs from airborne and shore-based video and radar observations.

- Develop and implement techniques to assimilate these data in Delft3D.

- Validate the assimilation model by hindcasting with the remote observations and sparse *in situ* data sampled from field experiments.

- Improve numerical model formulations to narrow error bands on model predictions

- Generate nowcasts and forecasts of the nearshore environment

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14. ABSTRACT
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APPROACH

The approach in this project is to develop an integrated modeling system that can be tested for a few sites where multiple information sources are available. We bring together a number of research groups with specific nearshore expertise, and experience with the suite of observations from different field sites including Duck (NC), Monterey (CA), La Jolla (CA), Egmond (NL), and Palm Beach (NSW). These field sites have distinctly different morphological characteristics and time-scales of response. Correspondingly, these sites have different remote sensing characteristics, which will provide an assessment of our proposed integrated modeling system's ability to nowcast and forecast in practical situations. This project is coordinated by Dano Roelvink and Stefan Aarninkhof at WL|Delft Hydraulics in the Netherlands. Ad Reniers at Delft University of Technology, The Netherlands, is supervising the application and development of Delft 3D to Palm Beach. A list of participants is given in table 1.

Table 1:Beach Wizard participants.

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The central software in the proposed system is the Delft3D model, which is available at NRL and for other ONR-sponsored institutions. This model is uniquely capable of modeling 2DH and 3D hydrodynamics and morphodynamic changes over time-scales ranging from wave groups to several weeks, at spatial scales resolving rip-current cells and breaker bars (Reniers et al., 2004). In particular, model application at Palm Beach, NSW has contributed significantly to our understanding of nearshore morphodynamic processes (Reniers et al, 2001) showing the strong correlation between spatial distribution of computed wave energy dissipation and observed video intensity on a alongshore variable nearshore bathymetry.

The starting point of this work is the estimation of improved nearshore bathymetry via an iterative data assimilation scheme. Assimilation of (forward) model runs with observations is achieved by adding artificial morphological processes to the processes already in place. At present, the additional processes extract or add sediment to the bottom according to the mismatch between remotely sensed proxies for a wave dissipation parameter and its modeled equivalent. The prediction's sensitivity to the data is tuned by adjusting the both the time scale of model adaptation and the data de-correlation time scale. A recent pilot study incorporating spatial variations of nearshore variables derived from Argus video data into the Delft3D model showed good results for both field observations (at Egmond, NL, and Monterey, CA) and synthetic case studies (Roelvink et al, 2003). We propose to further develop and test this assimilation method for nowcasting and prediction purposes, following a three-step approach:

A. **Development and ground truthing of the assimilation model.**

Improvement of algorithms to extract video-and radar-derived nearshore variables that can be assimilated with the Delft3D model. An initial focus on hindcasting will use data from the NCEX experiment (La Jolla, CA) that enables the simultaneous incorporation of both video and radar data. Ground truth data were obtained approximately weekly and indicated slowly evolving bathymetry in a complicated wave environment

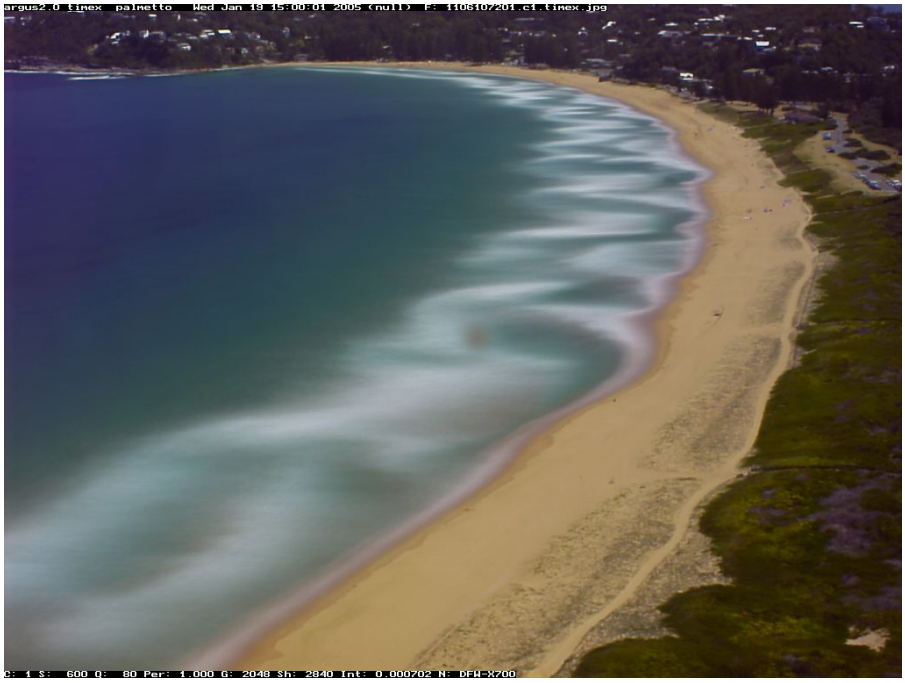

Figure 1: Time exposure image from Palm Beach, Sydney, Australia, obtained on Jan 19, 2005, showing a complex series of sand bars, shown by the whiter regions, and cut by deeper channels, shown by the darker regions.

B. **Nowcasting of coastal evolution.**

Application of the assimilation model to quantify the evolution of nearshore processes at a diverse set of morphodynamically active sites including Duck, a nourished beach at Egmond (NL), a rip-channeled beach at Monterey and Palm Beach, Australia (Figure 1). Model performance will be evaluated against regular bathymetrical surveys at the various sites, where available. Phase B aims to make predictions at locations with more temporal and spatial variability than NCEX. We expect that the added detail required by this task will come from improvement of the Beach Wizard's ability to assimilate an increased diversity of information sources, such as surface velocity estimates using PIV (Holland and Puleo, 2001).

C. **Forecast of coastal evolution.**

Model-based forecast of hydrodynamic processes and coastal evolution at the time scale of a single week to extrapolate the hindcast and now cast predictions. We assume that the predictability of coastal evolution is primarily limited by the uncertainties associated with the process-based morphological model. Forecasts will be improved by recursively iterating on model parameters or model formulations, through comparison with real-time remote observations. The sites of Egmond and Duck will be examples of reasonably active behaviour and a considerable ground-truth data.

The site of Palm Beach, Australia will be used as a typical example of a morphodynamically very active site with very good image quality but little ground truth data. An example of the type of complex morphology that can be observed on Palm Beach is shown in figure 1, a challenge for numerical simulation.

WORK COMPLETED

In June 2005 G. Symonds took up a new appointment with the Commonwealth Scientific and Industrial Research Organisation, Marine and Atmospheric Research, in Perth, Western Australia. He has retained formal connections with UNSW at ADFA through a Visiting Fellow appointment. As part of this move it was necessary to move the Palm Beach Argus server and image archive from ADFA to Perth in order to support the modeling and assimilation as applied to Palm Beach. A new server has been purchased and installed on the CSIRO network. The Palm Beach image archive has been transferred to this new server and the Argus image processing software installed.

RESULTS

During this first year incorporating the assimilation techniques and calibrating the hydrodynamic model has been undertaken by research partners at Delft Hydraulics and Delft University of Technology in the Netherlands. We are yet to apply the model to Palm Beach. Early in 2006 a student from DUT will spend time in Perth testing the model against sequences of time exposure video images from the Palm Beach archives.

IMPACT/APPLICATIONS

In addition to the importance to amphibious operations on beaches this research has obvious benefits to predicting and mitigating the effects of beach erosion and accretion due to natural causes and coastal development.

RELATED PROJECTS

Bluelink (http://www.marine.csiro.au/bluelink/) is a joint research effort between CSIRO, the Royal Australian Navy, and the Bureau of Meteorology, to deliver ocean forecasts for the Australian region. The highly successful first stage of this project is nearing completion with the delivery of a relocatable ocean model to the RAN. Bluelink2 is scheduled to begin in July 2006 with a particular emphasis on forecasting waves and currents in the littoral zone. Bluelink2 aims to combine numerical simulations with measurements of nearshore waves, currents and bathymetry using remote sensing techniques such as radar and video, and in situ instrumentation. The objectives of Bluelink2 are closely related to the Beach Wizard objectives providing the opportunity to apply the assimilation techniques in a more operational environment.

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